US LHC ACCELERATOR PROJECT

brookhaven - *fermilab* - *berkeley*

BROOKHAVEN NATIONAL LABORATORY

INTERIM DESIGN REVIEW for D3 & D4

Steve Plate

13 March 2001

Agenda

- Similarities:
  - D3 vs. D1/D2
  - D4 vs. D1/D2
- Design Differences / New Parts:
  - D3
  - D4
- Present Design Status
  - What's completed, D3 and D4
  - What's in-the-works, D3 and D4
  - What's not started, D3 and D4

Agenda (cont.)

- Electro-Mechanical Issues to be resolved
  - D3
  - D4
- Interface / Interconnect Issues to be resolved
  - D3
  - D4
- CERN-Supplied Parts
  - Status
  - Needs & Action Items
- Discussion of Issues

Similarities of D3 to D1/D2

- coil design & manufacture
  - quench heaters and leads (22AWG)
  - note: different conductor manufacturers
- yoke construction & prestressing
  - as in D1
- cold mass construction & welding
  - as in D1
- composite support posts from CERN
  - as in D2
- thermal shield, MLI blankets
  - as in D2

Similarities of D3 to D1/D2 (cont.)

- instrumentation feedthrough exit
  - same as D2 (but different contents)
- cryostat size
  - cross section same as D2
  - castings same as D2
- cryostat support
  - locations of support jacks
  - jack interface design
- survey & alignment
  - same as D2

Similarities of D4 to D1/D2

- coil design & manufacture
  - quench heaters and leads (22AWG)
  - note: different conductor manufacturers
- yoke construction & prestressing
  - as in D2
- cold mass construction & welding
  - as in D2
- composite support posts from CERN
  - as in D2
- thermal shield, MLI blankets
  - as in D2

Similarities of D4 to D1/D2 (cont.)

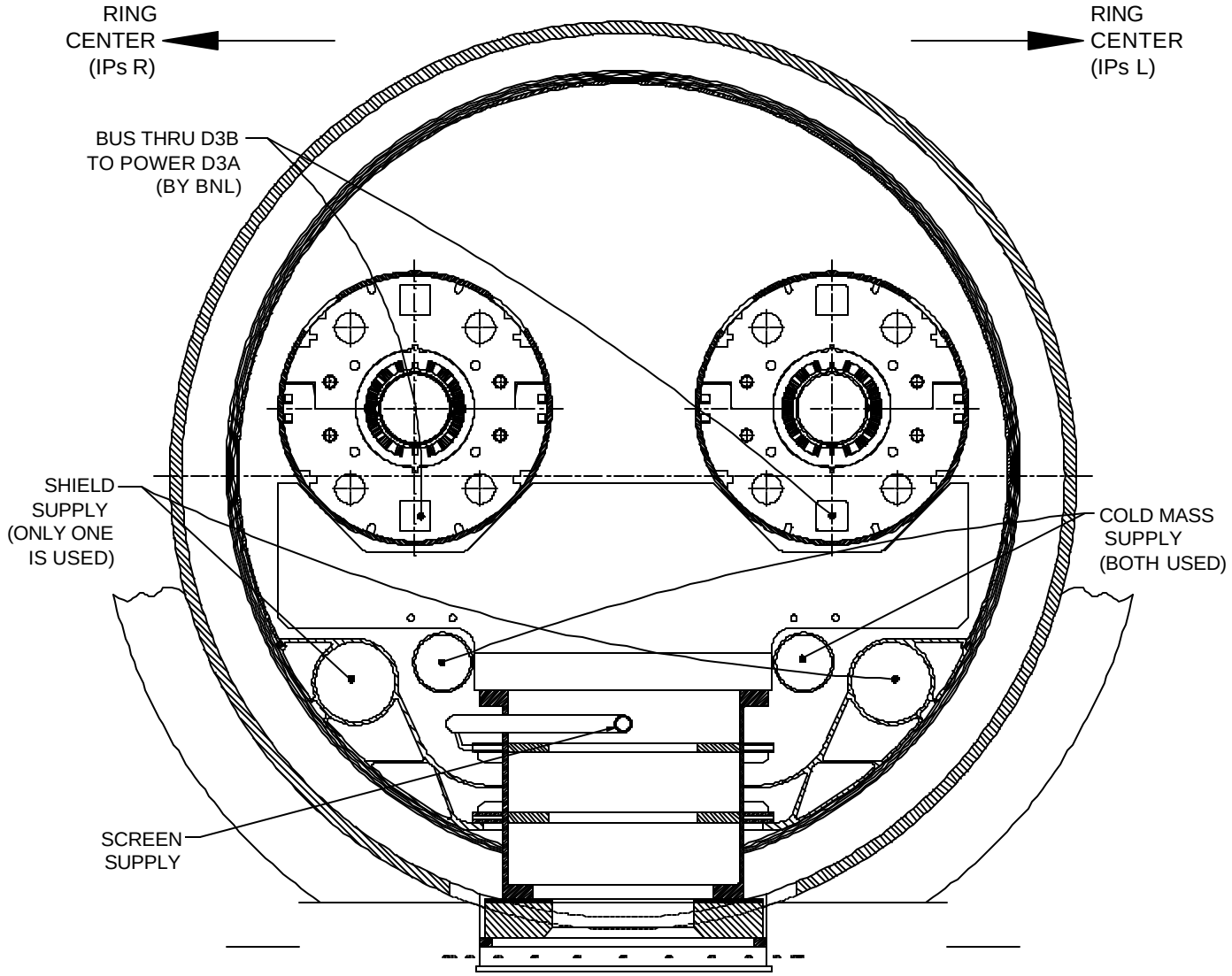
- instrumentation feedthrough exit
  - same as D2 (but different contents)
- cryostat size
  - cross section same as D2
  - castings same as D2
- cryostat support
  - locations of support jacks
  - jack interface design
- survey & alignment
  - same as D2

Differences in D3

- D3 Cold Mass Compared to D1:
  - Beam Tube Aperture
  - 4.5K operation
    - no phase separators or heat exchangers
    - level probes added
  - end volume plumbing connections
- D3 Cryostat Compared to D2:
  - Cradle design
    - support two cold masses on common posts
    - aperture spacings: 420, 382 cold
  - Internal piping (cross section)
  - Vacuum vessel design
    - length and fixed/sliding flange locations vary

D3a/b

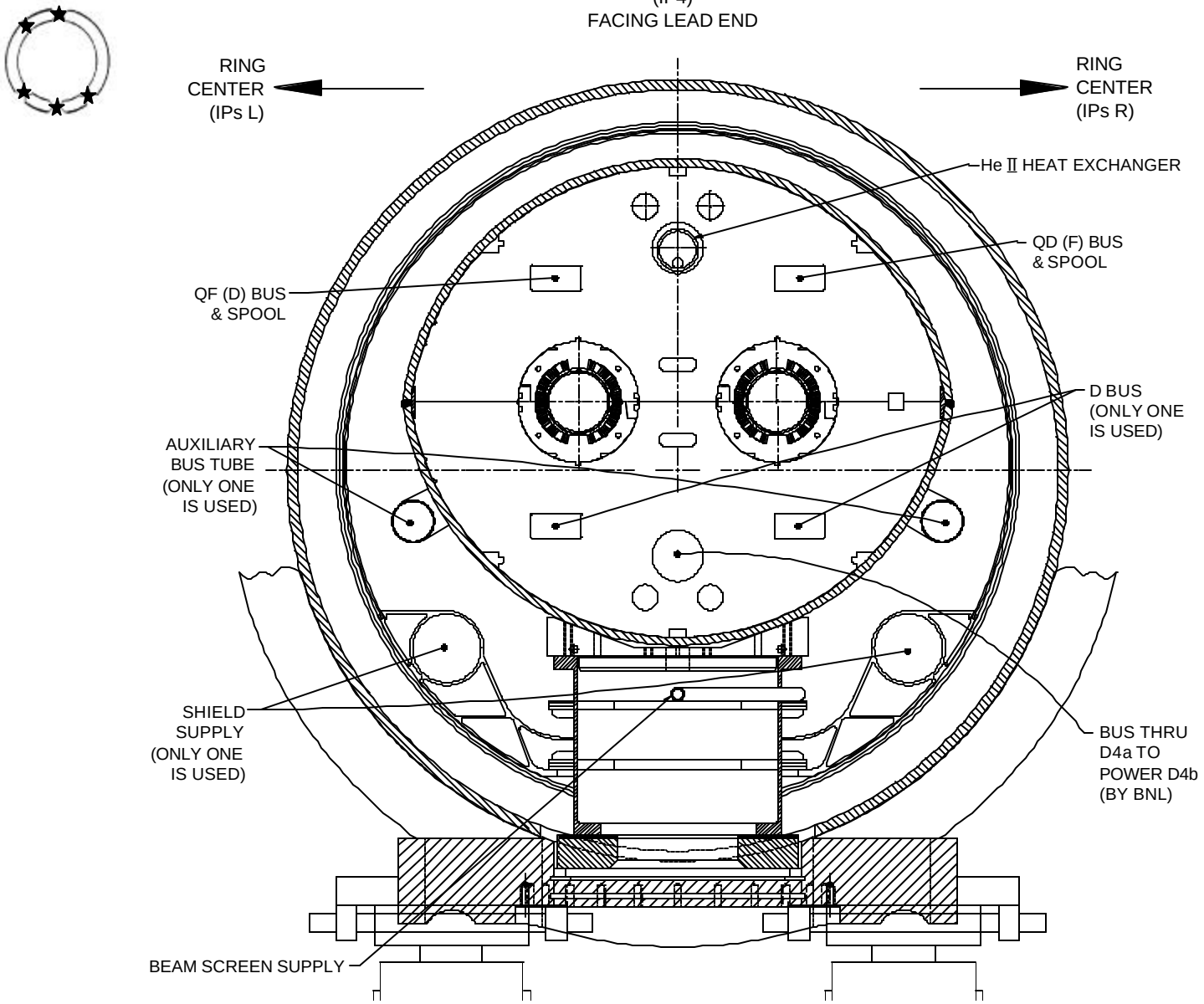
(IP4)
FACING LEAD END



Differences in D4

- D4 Cold Mass Compared to D2:
  - aperture spacing: 232, 194 cold
  - 1.9K operation
    - no level probes
    - heat exchanger tube in yoke (from CERN)
    - phase separator is part of CERN QQS
    - CERN-designed electrical buses for power to magnets beyond
    - many flex joints in end volumes!
    - specific instrumentation provided
- D4 Cryostat Compared to D2:
  - end flange location/configuration
  - CERN auxiliary bus tube (two; one redundant) (cross section)
  - attachment of QQS modules later by CERN

D4a/b


(IP4)
FACING LEAD END
RING CENTER (IPs L)
RING CENTER (IPs R)
He II HEAT EXCHANGER
QD (F) BUS & SPOOL
QF (D) BUS & SPOOL
D BUS (ONLY ONE IS USED)
AUXILIARY BUS TUBE (ONLY ONE IS USED)
SHIELD SUPPLY (ONLY ONE IS USED)
BUS THRU D4a TO POWER D4b (BY BNL)
BEAM SCREEN SUPPLY

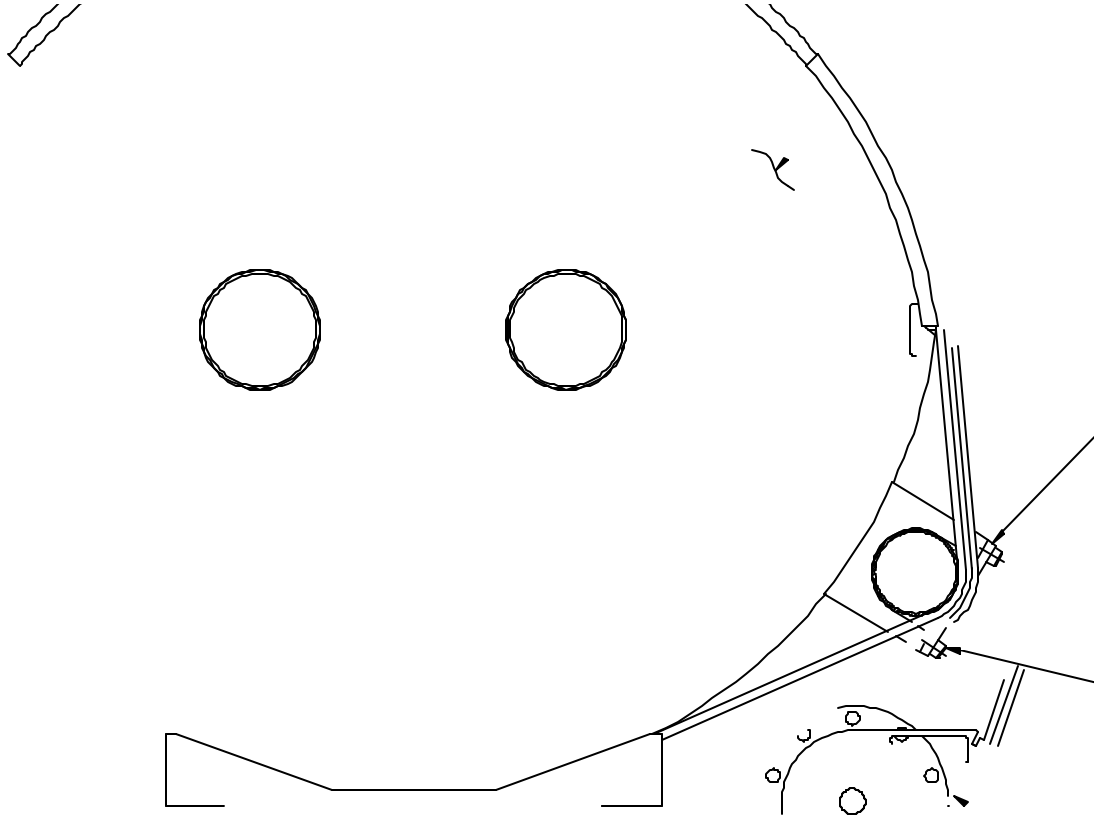
Design Status: New Items, Completed

- D1 & D2 Photos
- Completed on D3
  - instrumentation design
    - quench heaters
    - yoke thermometers (to be sent by CERN)
    - He level probes (AMI, Inc.)
    - voltage taps (primary & redundant; wire on order)
    - yoke heaters (on-hand)
  - cryostat drawings
  - “in-common” items

New Items, Completed (cont.)

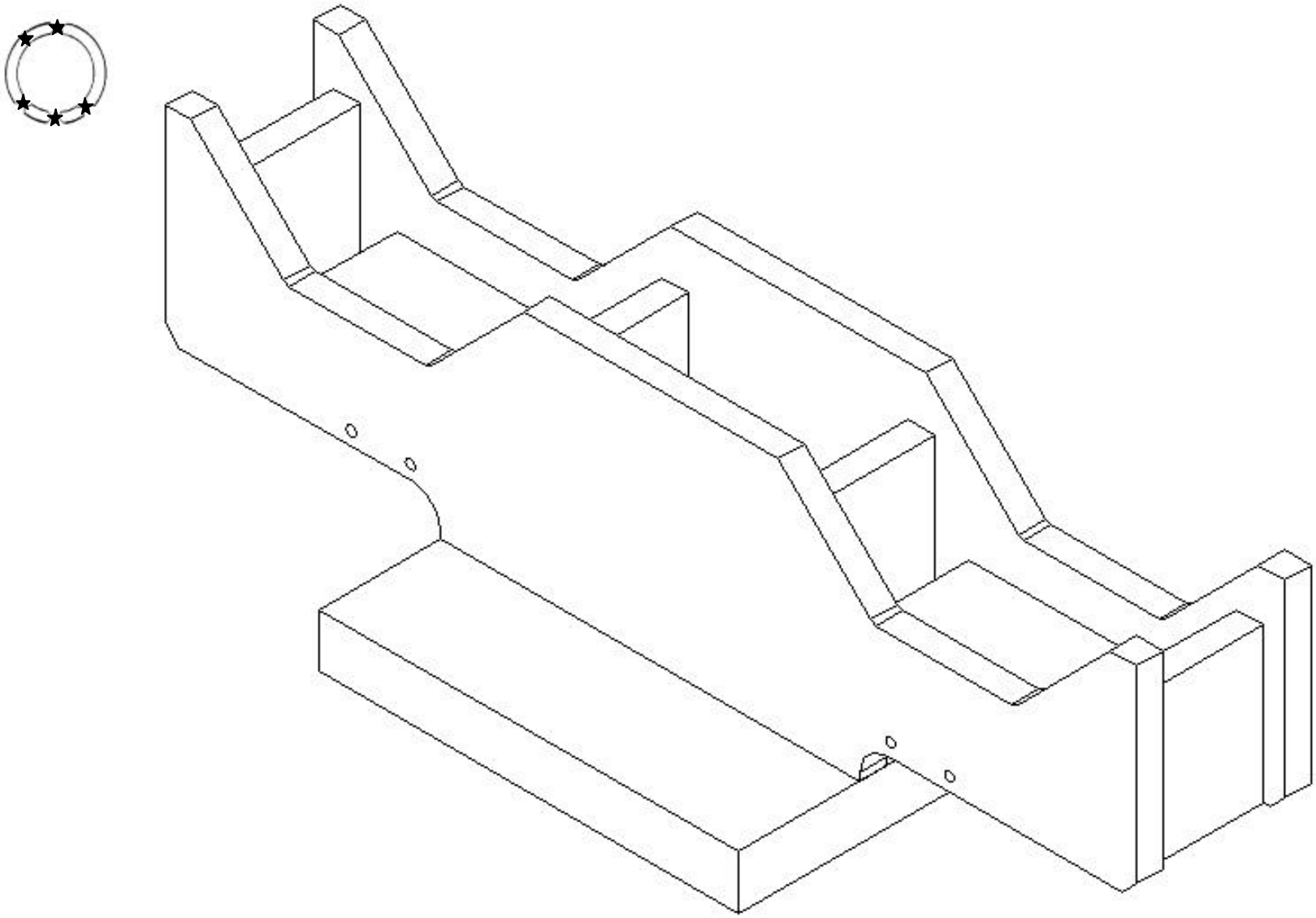
- Completed on D4
  - instrumentation design
    - quench heaters
    - yoke thermometers (to be sent by CERN)
    - voltage taps (primary & redundant; wire on order)
    - yoke heaters (on-hand)
  - mounting of auxiliary bus tube (cross section)
  - cryostat drawings (out for bid)
  - “in-common” items

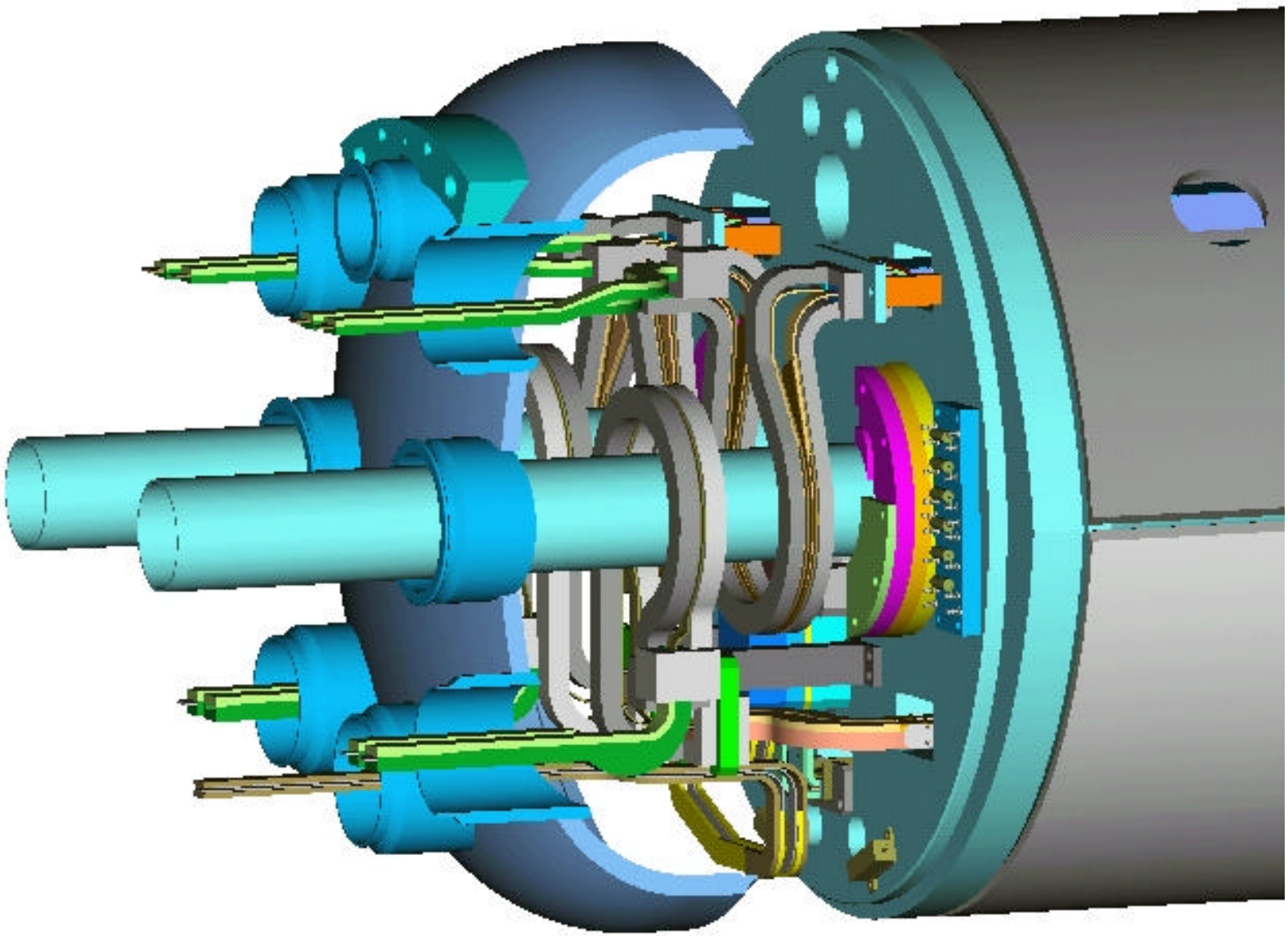
Auxiliary Bus Tube & Mount



New Items, In-the-Works

- In-the-Works on D3
  - cold mass support cradle (iso dwg)
- In-the-Works on D4
  - flex joint details, D4a (flex joints one end) (3D model)
  - D4b will follow shortly (flex joints both ends)
  - length of, and connections to, electrical through-buses from CERN
  - length of, and connections to, BNL-provided through-bus to D4b
  - splice lengths/areas





New Items, Not Started

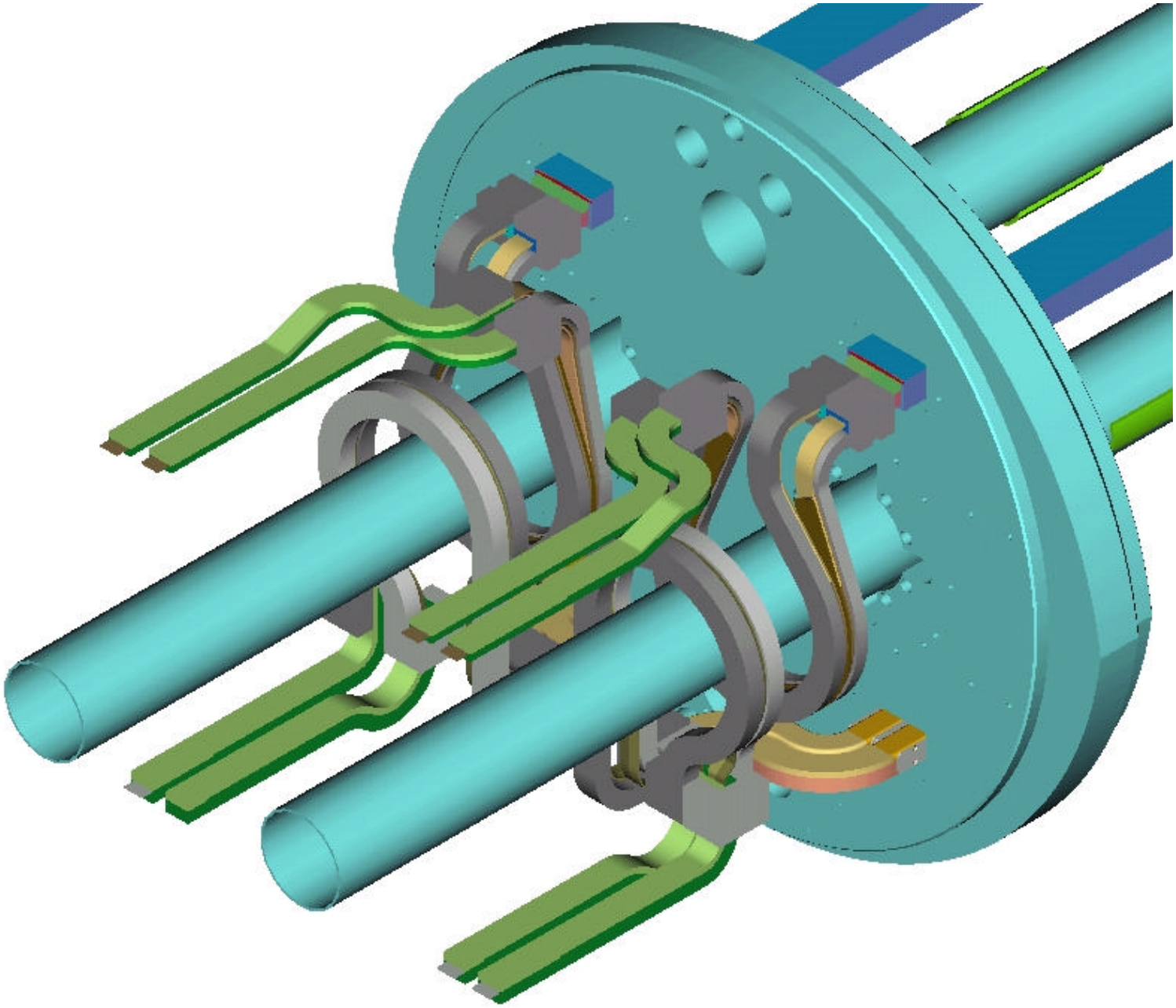
- Not Started on D3
  - length of, and connections to, BNL-provided through-bus to D3a
  - instrumentation feedthrough
  - beam screen supply pipe (c') mounting (no intercept on cold mass cradle)
  - end volume inlets/outlet plumbing

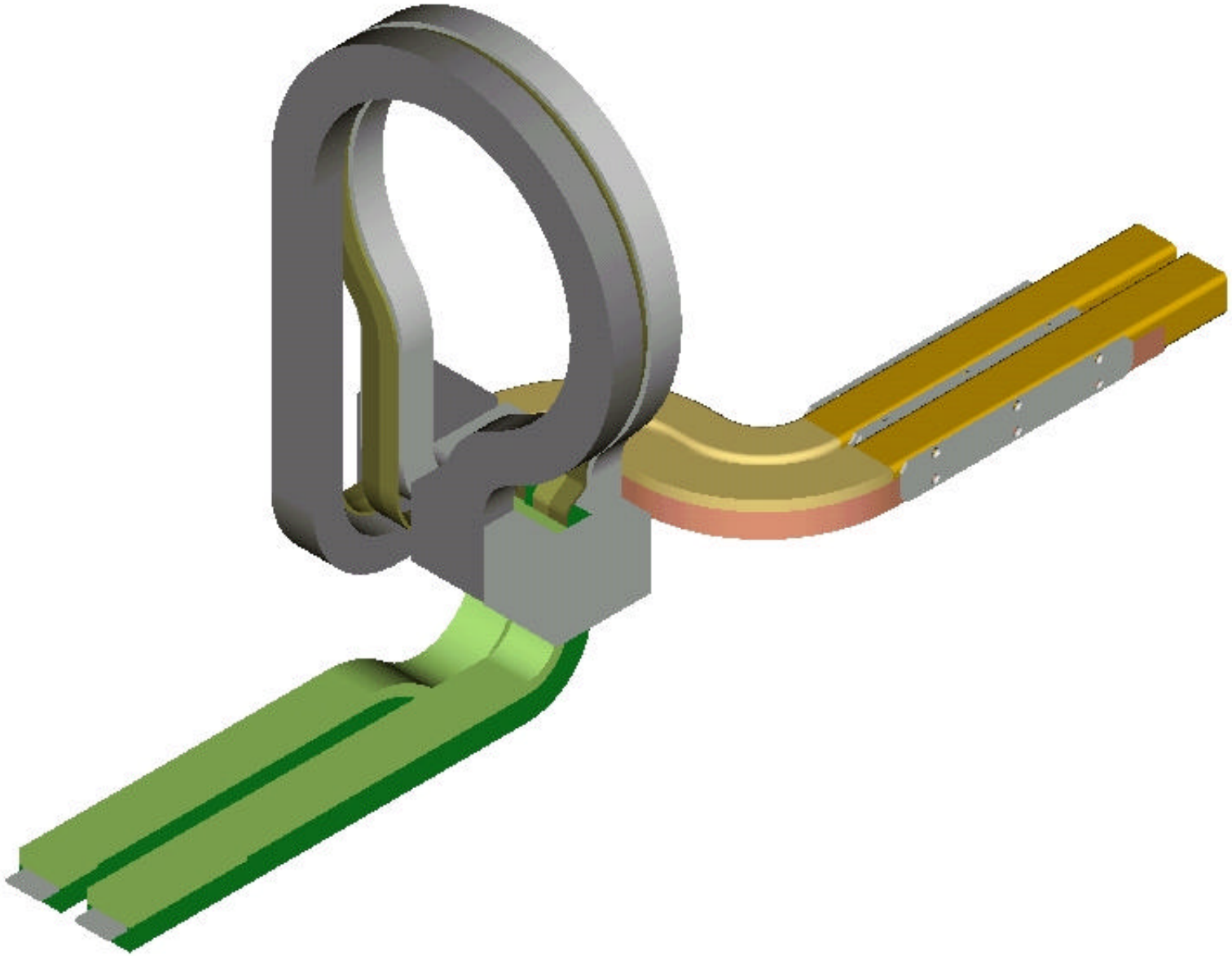
New Items, Not Started (cont.)

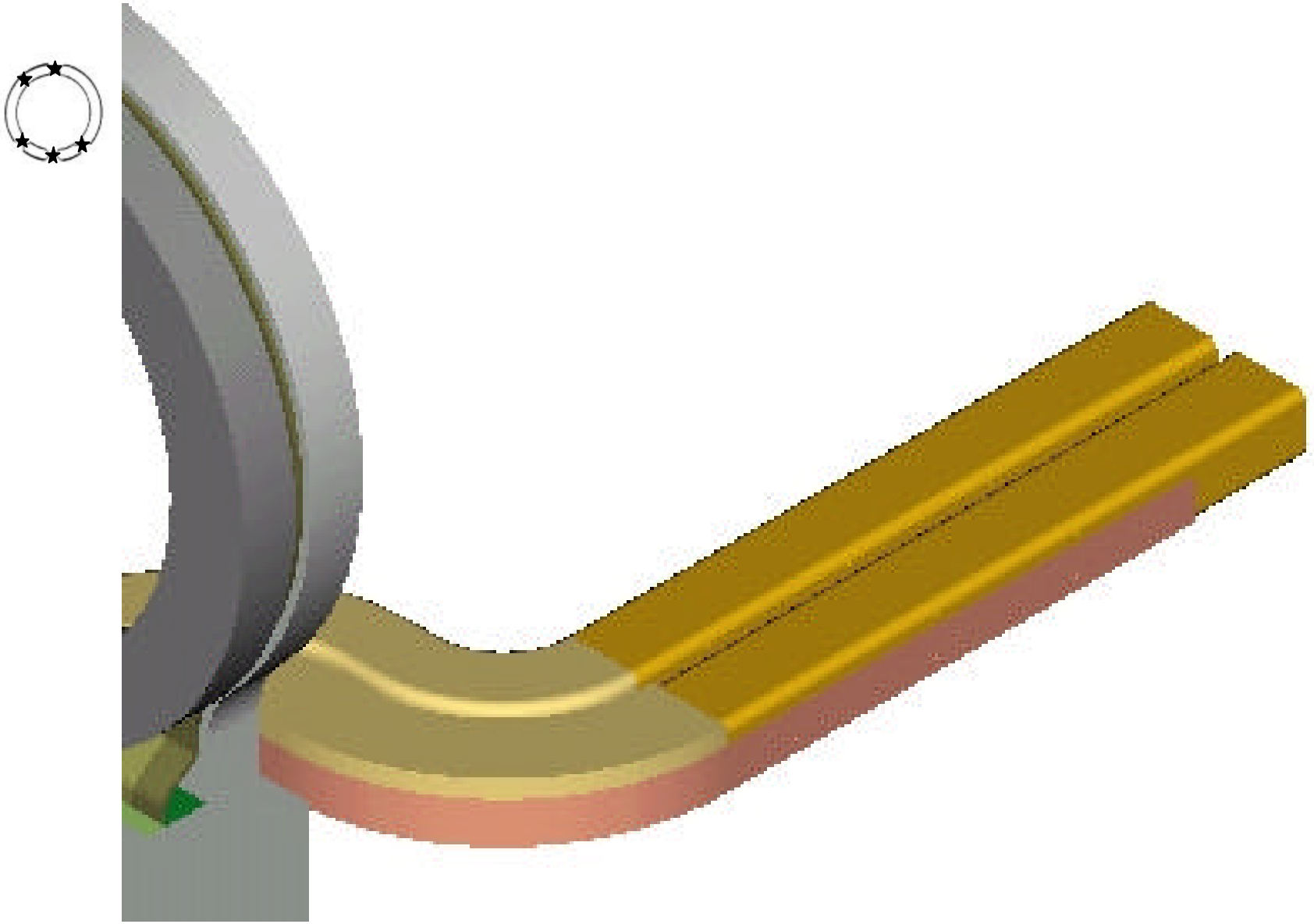
- Not Started on D4
  - instrumentation feedthrough
  - end volume inlets/outlet plumbing
  - heat exchanger tube terminations

Electro-Mechanical/End Volume Issues

- Regarding D3
  - are there any?
- Regarding D4
  - design and supply of CERN-style through-buses
    - 2 dipole, 2 quad per magnet; 12 each total (J-L Perinet-Marquet)
    - machining at ends to mate with flex joints (3D model)
    - joint designs & contact areas
    - BNL to give overall bus lengths required
    - delivery schedule : required by October 2001







Interconnect / Interface Issues

- Regarding D3
  - cryostat/QQS interface
    - flange configurations and lengths (spreadsheet)
    - assembled by CERN after magnet is shipped
  - cryogenic piping change for beam screen cooling
    - cooling schematics
  - instrumentation feedthrough
    - % of tube fill necessary
    - design and supply of warm feedthrough
    - parameters that determine length - make same length as standard CERN arc feedthrough?
  - design & supply of interconnect bellows
    - standard CERN sizes at rated pressures

D4 at IR4 Right

Cold Mass			Cryostat					
dz	z		dz	z	Lgth CM beyond cryostat		Flange type	Comments
	0	Q7-D4b Interface plane		0				
								810 mm bellows, off-ctr on D4-Q7 interface, stores on D4
-258	-258	D4b non-lead end	-550	-550	292	D4b non-lead end	sliding	
-10386	-10644	D4b lead end	-9802	-10352	292	D4b lead end	sliding	
-258	-10902	D4a-D4b interface plane	-550	-10902				1100 mm bellows centered on D4a-b interface
-258	-11160	D4a non-lead end	-550	-11452	292	D4a non-lead end	sliding	
-10386	-21546	D4a lead end	-9802	-21254	292	D4a lead end	sliding	Standard CM - cryostat end distance

D4 at IR4 Left

Cold Mass			Cryostat					
dz	z		dz	z	Lgth CM beyond cryostat		Flange type	Comments
	0	Q7-D4b Interface plane		0				
								1100 mm bellows, ctrd on D4-Q7 interface, stores on Q7
258	258	D4b non-lead end	550	550	292	D4b non-lead end	sliding	
10386	10644	D4b lead end	9802	10352	292	D4b lead end	sliding	
258	10902	D4a-D4b interface plane	550	10902				1100 mm bellows centered on D4a-b interface
258	11160	D4a non-lead end	550	11452	292	D4a non-lead end	sliding	
10386	21546	D4a lead end	9802	21254	292	D4a lead end	sliding	Standard CM - cryostat end distance

D3 at IR4 Right

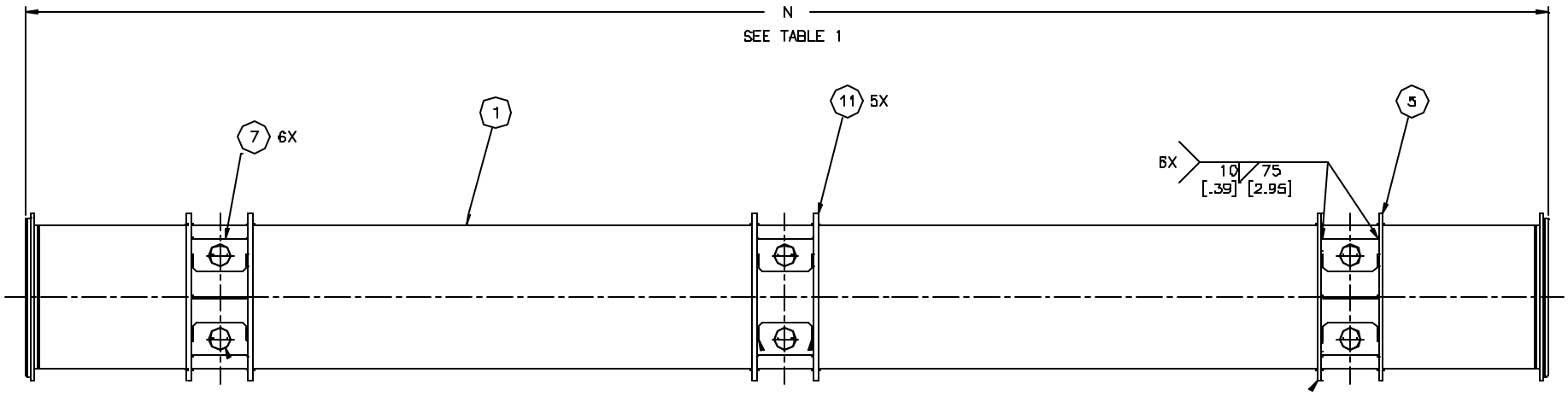
Cold Mass			Cryostat					
dz	z		dz	z	Lgth CM beyond cryostat		Flange type	Comments
	0	DFBA - D3b int plane		0				
								810 mm bellows, off-ctr on D3-DFB interface, stores on D3
-258	-258	D3b lead end	-550	-550	292	D3b lead end	sliding	
-10230	-10488	D3b non-lead end	-9646	-10196	292	D3b non-lead end	sliding	
-258	-10746	D3a-D3b interface plane	-550	-10746				1100 mm bellows centered on D3a-b interface
-258	-11004	D3a lead end	-550	-11296	292	D3a lead end	sliding	
-10230	-21234	D3a non-lead end	-9646	-20942	292	D3a non-lead end	sliding	Standard CM - cryostat end distance

D3 at IR4 Left

Cold Mass			Cryostat					
dz	z		dz	z	Lgth CM beyond cryostat		Flange type	Comments
	0	DFBA/QQS - D3b int pl		0				
								810 mm bellows, off-ctr on D3-QQS interface, stores on D3
258	258	D3b lead end	550	550	292	D3b lead end	sliding	
10230	10488	D3b non-lead end	9646	10196	292	D3b non-lead end	sliding	
258	10746	D3a-D3b interface plane	550	10746				1100 mm bellows centered on D3a-b interface
258	11004	D3a lead end	550	11296	292	D3a lead end	sliding	
10230	21234	D3a non-lead end	9646	20942	292	D3a non-lead end	sliding	Standard CM - cryostat end distance

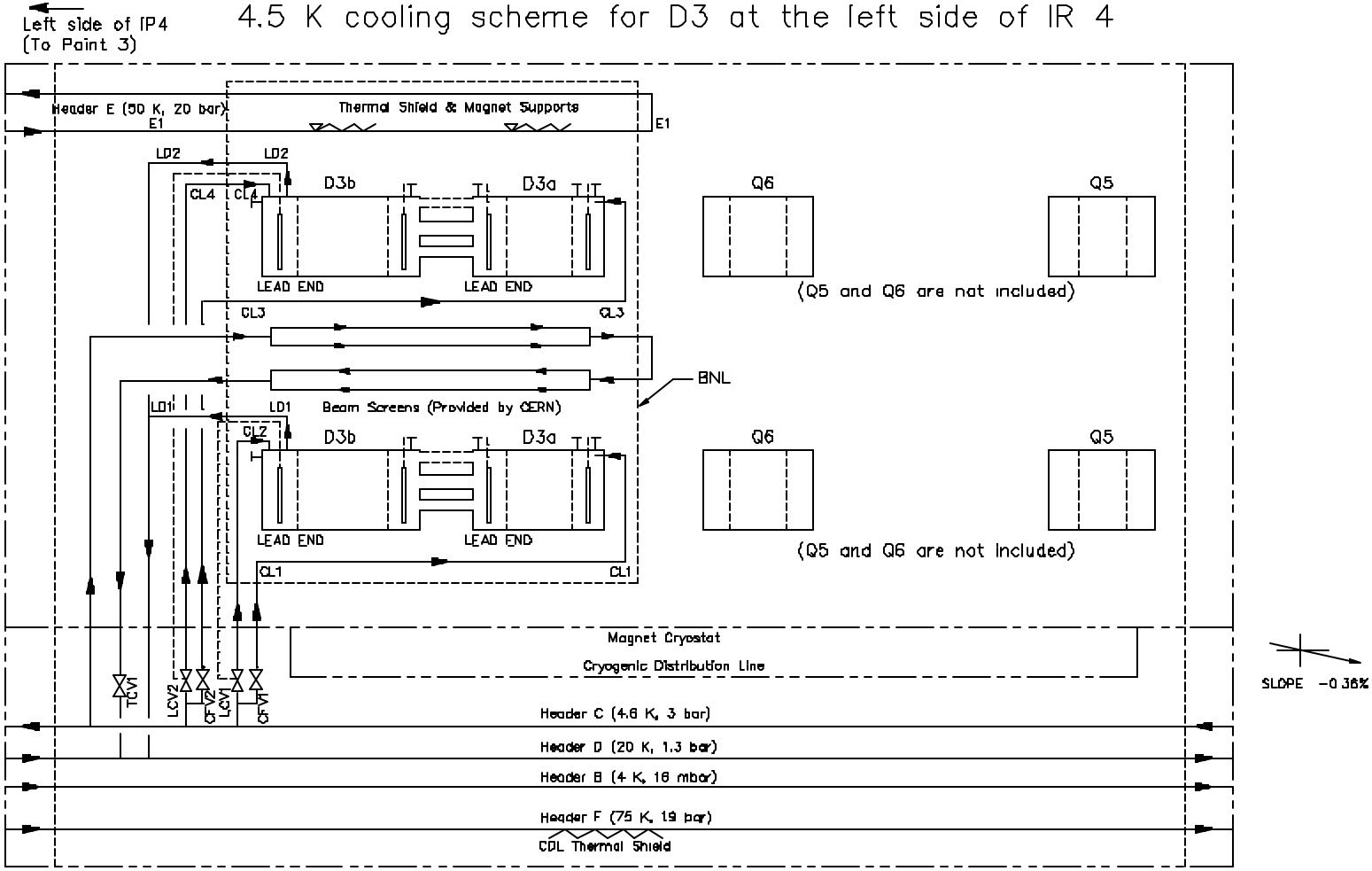
D2, IRnL

Cold Mass			Cryostat					
dz	z		dz	z	Lgth CM beyond cryostat		Flange type	Comments
	0	Q4-D2 interface plane		0				
								1100 mm bellows, ctrd on D2-Q4 interface, stores on Q4
258	258	D2 lead end	550	550	292	D2 lead end	sliding	
10386	10644	D2 non-lead end	9784	10334	310	D2 non-lead end	fixed	mini-QQS is being designed for this dimension


N
SEE TABLE 1
7 6X
1
11 5X
5
6X
10
[.39]
75
[2.95]

Flow diagram includes extra level gauge and nozzles for spare and for test in MAGCOOL 2/8/01

4.5 K cooling scheme for D3 at the left side of IR 4

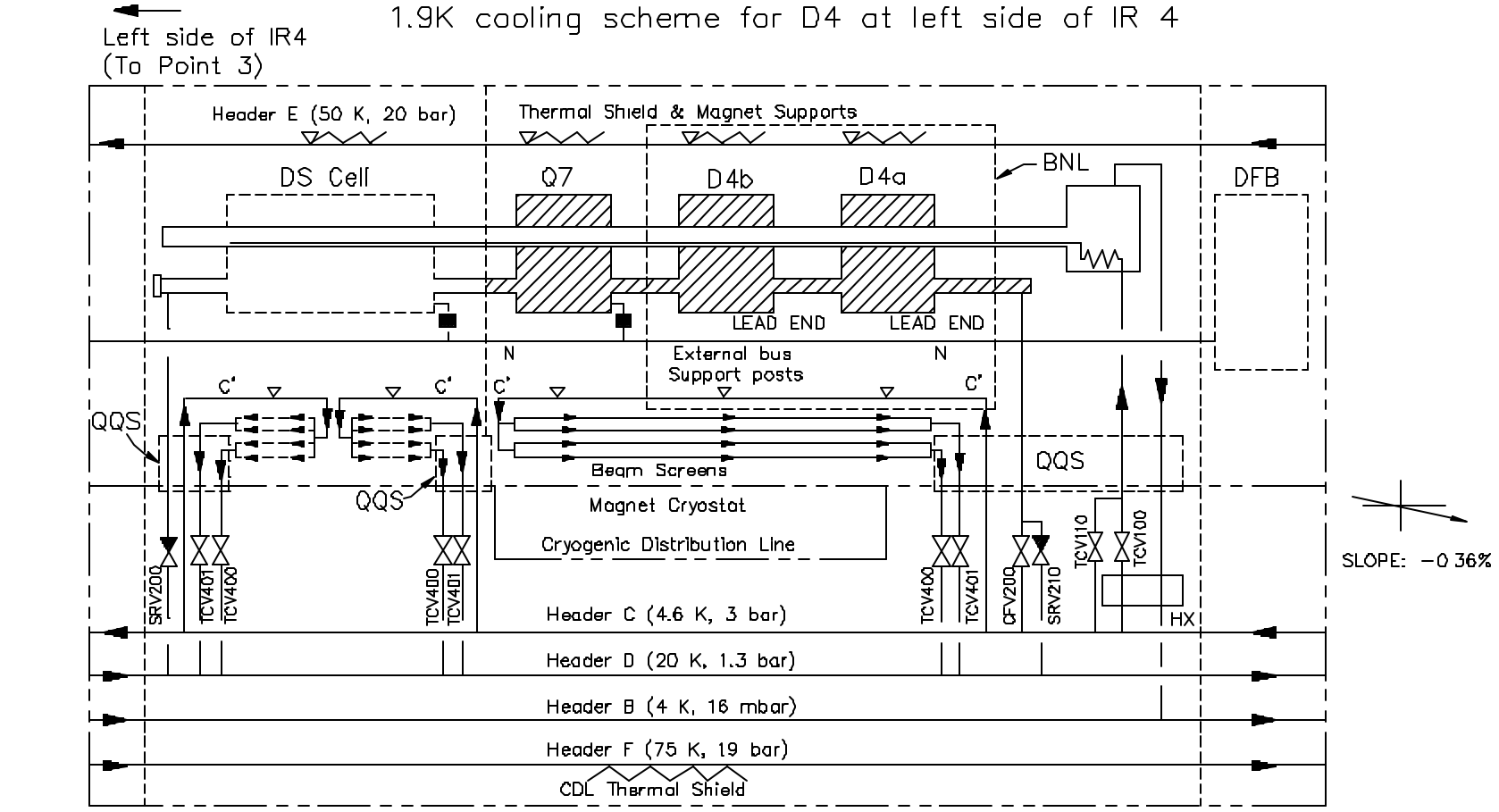


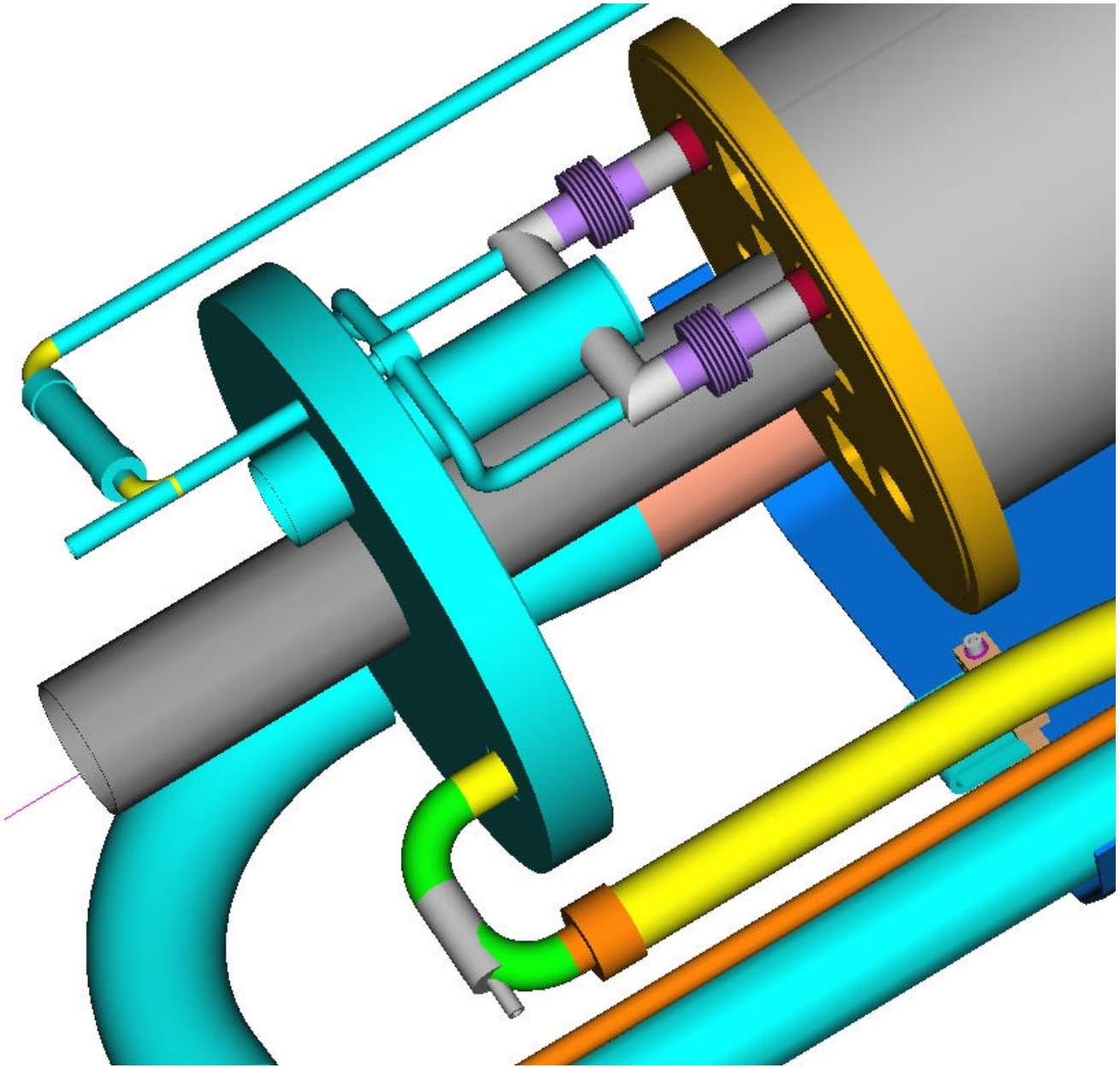
D3 to DFBA INTERCONNECT ELEMENTS

D3 bellows intercon forces.xls			S.Plate		8-Mar-01			
COLD MASS PIPING/TUBING LINES:								
LINE	NOTES	FLEXIBLE ELEMENT	ELEMENT SUPPLIED BY	BELLOWS CONV. ID	BELLOWS CONV. OD	PRESSURE AREA (mean dia)	TEST PRESSURE (psia)	FORCE (lbs)
LD	2" OD						375	
$CL_{2(4)}$	1" OD						375	
m/c	P/N 01055055	bellows	BNL (RHIC design)	3.56	4.06	11.40	375	4273
i	flange P/N 14010306	FHC or HL*	BNL			0.00	375	0
								4273
CRYOSTAT PIPING/TUBING LINES:								
LINE	NOTES			BELLOWS CONV. ID	BELLOWS CONV. OD	PRESSURE AREA (mean dia)	TEST PRESSURE (psia)	FORCE (lbs)
$CL_{1(3)}$	1" OD					0.00	375	0
e_1	80 mm ID	bellows					412	
								0
		*"FHC or HL" = Flex Hose Catenary or Hard Loop; TBD						
							Two Cold Masses At Test Pressure: TOTAL FORCE:	**8546**

Interconnect / Interface Issues (cont.)

- Regarding D4
  - cryogenic piping change for beam screen cooling
    - cooling schematics
  - 1.9K heat exchanger tube (D1 model as example only)
    - overall length
    - design at ends; connection to end volume
    - location of transition to SST
    - installation of cy tube by which lab?
  - cryostat/QQS interface
    - flange configs and lengths (spreadsheet)
    - assembled by CERN after magnet is shipped
    - CERN buses to have length added to copper after shipment, but superconductor will be full length. What is the length of superconductor needed to avoid a splice?


1.9K cooling scheme for D4 at left side of IR 4
Left side of IR4
(To Point 3)
Header E (50 K, 20 bar)
Thermal Shield & Magnet Supports
DS Cell
Q7
D4b
D4a
BNL
DFB
LEAD END
LEAD END
N
External bus
Support posts
N
C'
C'
C'
C'
QQS
QQS
QQS
Beam Screens
Magnet Cryostat
Cryogenic Distribution Line
SRV200
TCV401
TCV400
TCV400
TCV401
TCV400
TCV401
CFV200
SRV210
TCV110
TCV100
HX
SLOPE: −0.36%
Header C (4.6 K, 3 bar)
Header D (20 K, 1.3 bar)
Header B (4 K, 16 mbar)
Header F (75 K, 19 bar)
CDL Thermal Shield



D4 Interconnect / Interface Issues (cont.)

- instrumentation feedthrough as with D3
- design & supply of interconnect bellows
  - standard CERN sizes at rated pressures

D4 to DFBA INTERCONNECT ELEMENTS

D4 bellows intercon forces.xls | S.Plate | 8-Mar-01

COLD MASS PIPING/TUBING LINES:

LINE	NOTES	FLEXIBLE ELEMENT	ELEMENT SUPPLIED BY	BELLOWS CONV. ID	BELLOWS CONV. OD	PRESSURE AREA (mean dia)	TEST PRESSURE (psia)	FORCE (lbs)
xb	test IP=75; test OP=375						375	0
M_1							375	0
M_2							375	0
M_3							375	0
m/c	P/N 01055055	bellows	BNL (RHIC design)	3.56	4.06	11.40	375	4273
i	flange P/N 14010306	FHC or HL*	BNL			0.00	375	0
								4273

CRYOSTAT PIPING/TUBING LINES:

LINE	NOTES	FLEXIBLE ELEMENT	ELEMENT SUPPLIED BY	BELLOWS CONV. ID	BELLOWS CONV. OD	PRESSURE AREA (mean dia)	TEST PRESSURE (psia)	FORCE (lbs)
c		bellows					375	
c'		FHC or HL*				0.00	375	0
N	aux bus tube	FHC or HL*	CERN			0.00	375	0
e_1		bellows						
								0

*"FHC or HL" = Flex Hose Catenary or Hard Loop; TBD

At Test Pressure: TOTAL FORCE: 4273

CERN Parts to BNL

LIST OF PARTS TO BE PROVIDED TO BNL BY CERN

02-Feb-01 S. Plate

Cernsupp.xls

ITEM	DWG NO.	CERN CONTACT	MAG TYPE	INITIAL QTY	by DATE	BALANCE QTY	by DATE	STATUS	NOTES
End Covers (blank; no holes)	?	Frederic Savary	D2, D4	4	01-Jul-00	26	15-Dec-00	Rec'd 20	2 shipments (2 + 18)
Beam Tubes, 78mm & 73 mm OD	14010093, 14010166	Frederic Savary	D1,D2, D3,D4	10, 50	01-Oct-00	N/A	N/A	rec'd 5 D1 tubes	
Heat Exchanger Tubes, 58 mm OD	?	Frederic Savary	D4	6	01-Jun-01	N/A	N/A		BNL to give length reqmt
Dipole Cryostat Cradle (casting)	LHCQBA_ S0002	Lloyd Williams, Mikael Sjoholm	D2,D3,D4	63	01-Aug-00	N/A	N/A	**rec'd all (65)**	**COMPLETE**
Heat Shield Assy (thermal trays) (length for BNL to be 11000 mm)	~LHCQBA_P0007	Lloyd Williams, Mikael Sjoholm	D2,D3,D4	21	01-Jul-00	N/A	N/A	**rec'd all (22)**	**COMPLETE**
Dipole Support Posts, Ctr. & Extr.	LHCQBH_P0019, LHCQBH_P0020	Vittorio Parma	D2,D3,D4	21, 42	01-Jul-00	N/A	N/A	Rec'd 2,4	
Dip Bus Assy (straight; cu length for BNL to be 11000 mm)	~LHCDCBAA0007	J-L Perinet-Marquet	D4	12	01-Mar-01	N/A	N/A	send sketch to J-L P-M	length given is copper only; extra super-conductor and trim leads (300 mm at each end) to be coiled up.
Quad Bus Assy (straight; cu length for BNL to be 11000 mm)	~LHCDCQAA0008	J-L Perinet-Marquet	D4	12	01-Mar-01	N/A	N/A		
Superconductor for 13,000A Lyre	1.36 x 1.6 x 15.1	J-L Perinet-Marquet	D4	?	01-Jun-00	N/A	N/A	Rec'd 10 m	**COMPLETE**
Temperature Sensors, Cold Mass	?	Juan Casas, Christoph Balle	D1,D2, D3,D4	2/mo	01-Jun-00	20	01-Jul-02	Rec'd 22	9 m lead length, calibrated; 70 total
Warm-up Heaters		Juan Casas, Troels Bager	D1,D2, D3,D4	50	15-Feb-00	20	01-Dec-00	**rec'd all 70**	**COMPLETE**
Taylor-Hobson Fiducial "Cups"	LHCGIMSA0003	J-P Quesnel	D1,D2, D3,D4	6	15-Oct-00	150	01-Jan-01		

"~" indicates similar to part listed but not identical; variation noted.

CERN drawing number is given as a reference to help identify the part needed.

CERN Parts at CERN

PARTS SUPPLIED BY CERN BUT REMAINING AND USED THERE:

Beam Screen
Warm/Cold Transition
Support Post Radiation Discs
Vacuum Vessel Support Covers
Vacuum Vessel Relief Valves
Standard Interconnect Bellows
Taylor-Hobson Balls & Spheres
Vacuum Vessel Flange O-Rings (for 24" and 36" vessels)
"PMPS" Jacks

sheet 2 of 2

Parts Supply - Action Items

- The following parts are needed quickly to support production at Brookhaven:
  - 73 mm beam tubes
  - support posts beyond the first two D2 magnets
- The following are less critical, but needed soon:
  - T-H fiducial “cups”, dwg #LHCGIMSA0003